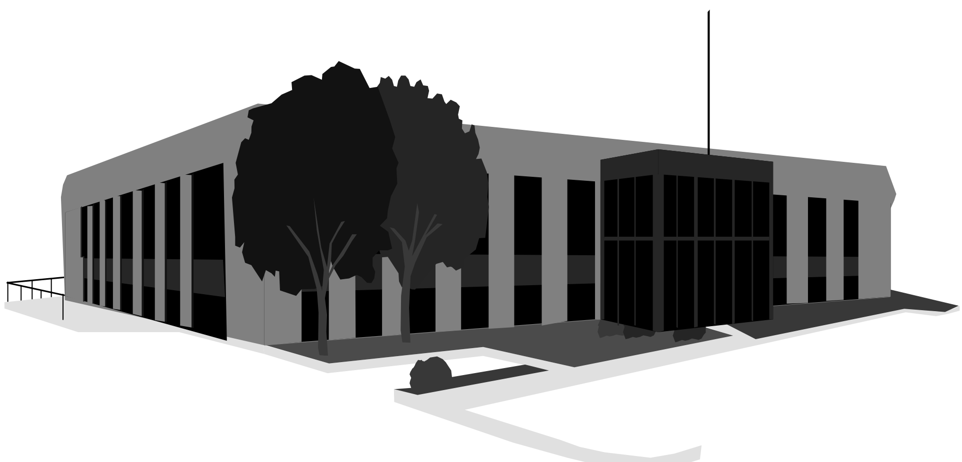
INDOOR AIR QUALITY ASSESSMENT

Department of Revenue
110 Mulberry Street
Brockton, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
December, 2000

Background/Introduction

In response to a request from Rosemary Day, Deputy Commissioner of the Department of Revenue (DOR), an indoor air quality assessment was done at the DOR facility at 110 Mulberry Street, Brockton, Massachusetts. This assessment was conducted by the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA). BEHA staff received complaints of headaches, exacerbation of allergies, rashes, eye, throat and skin irritation that occupants believed to be attributed to the building.

On August 31, 2000, a visit was made to this building by Cory Holmes, Environmental Analyst of the Emergency Response/Indoor Air Quality (ER/IAQ) Program. The DOR has occupied the second floor office space for the past year. Prior to occupying the second floor the DOR was located on the first floor. Staff complaints began shortly after the move to the second floor. Currently the first floor is unoccupied; however, it was reported by DOR personnel that following renovations, the Department of Social Services will reportedly occupy the space.

OccuHealth, Inc. conducted an indoor air quality assessment prior to the BEHA visit. The OccuHealth report recommended the following: (1) all of the fiberglass insulation above ceiling tiles be inspected and damaged materials be removed and replaced, (2) efforts should continue to prevent future building leaks and subsequent water damage events, (3) all water-damaged building materials including wallboard and carpeting be removed and replaced, and (4) the rooftop fresh air damper controlling rooftop unit 3 be repaired (OccuHealth, 2000).

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor.

Results

The DOR has a maximum population of approximately 50-100 on a daily basis. The tests were taken under normal operating conditions. Test results appear in Tables 1-5. Air samples are listed in the tables by location that the air sample was taken or by the name of the person who occupies the area.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were above 800 parts per million parts of air [ppm] in two of forty areas sampled throughout the second floor. These carbon dioxide levels are indicative of adequate air exchange in most of the areas sampled. However, it is also important to note that windows were open in a number of areas during the assessment, which can reduce carbon dioxide levels.

A heating, ventilation and air conditioning (HVAC) system provides ventilation. Fresh air is provided by rooftop-mounted air-handling units (AHUs) and distributed to zoned areas through insulated ductwork located in the ceiling plenum above the suspended ceiling throughout the second floor. Flexible ductwork branches off the main duct to deliver air to work stations through ceiling-mounted, multi-directional air diffusers (see Picture 1). It is important to note that in many instances flexible ductwork was not connected to air diffusers but delivered air directly above them. This configuration (an "open" system) can result in uneven air delivery and can introduce particulates from the ceiling plenum into occupied areas (see Other Concerns).

Exhaust ventilation is provided by ceiling-mounted exhaust grilles, which return air to the AHUs via ductwork (see Picture 2). A number of AHUs were in the off cycle during portions of the assessment. DOR personnel reported one of the AHUs was deactivated and was scheduled for replacement. As previously mentioned, a number of windows were open during the assessment allowing the infiltration of hot outside air (background temp 82^{o} F). The infiltration of hot outside air raises interior temperatures, resulting in thermostats deactivating the AHUs. Without operating AHUs, fresh outside air is not distributed via the HVAC system.

DOR staff reported that AHUs are planned to be replaced during a conversion of the heating system to natural gas. Replacement of air handling equipment should improve temperature control and provide for better circulation of air. The BEHA has offered to revisit the building once renovations are complete, to conduct a follow-up assessment.

In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air. The date of the last servicing and balancing of the HVAC systems was not available at the time of the visit.

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature measurements ranged from 68^{o} F to 75^{o} F, which were close to the BEHA recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. A number of complaints of uneven heating and cooling were expressed to BEHA staff. Temperature measurements in the north side of the floor were several degrees cooler than other areas assessed (see Table 1). A thermostat was observed near the rear of the north area mounted on a support column directly above a laser printer (see Picture 3). Heated air rising from the laser printer would activate the thermostat, which would in turn activate the HVAC system to provide cold air to this area during summer months. In winter, the HVAC system would be deactivated by heated air from the laser printer interacting with the sensors in the thermostat. The location of the thermostat in combination with open windows, mentioned previously, makes it difficult for the ventilation system to control temperature. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

As mentioned previously, supply ductwork was not connected to air diffusers, which can allow air to bypass diffusers, forcing air directly on occupants seated below the air diffusers. In some areas air diffusers were blocked with masking tape and/or cardboard (see Picture 4) in an effort to control drafts. This alteration of the system, however, can throw the system off-balance and create uneven heating/cooling conditions in other areas adjacent to the blocked diffuser.

The relative humidity in this building ranged from 49 to 61 percent, which was within the BEHA recommended comfort range for most areas. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. As mentioned previously, a number of windows were open during the assessment. During periods of high relative humidity (late spring/summer months), windows and exterior doors should be closed to keep outdoor moisture from penetrating into the building. In addition, the ventilation system should be activated to remove moist air in the building. Please note that relative humidity levels in the DOR would be expected to drop during the winter months due to heating and decreased outdoor relative humidity concentrations. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Stained ceiling tiles were observed in some areas. The file room appears to be an area of reoccurring water damage. DOR staff affixed plastic sheeting over boxes and records to protect them from water damage. Plastic sheeting was also configured in a manner to direct water into trash receptacles placed below areas of potential leaks (see Picture 5). Water-damaged ceiling tiles can be a medium for mold and mildew growth and should be replaced after a water leak is discovered. DOR staff reported water damaged ceiling tiles and ductwork insulation attributed to roof leaks. DOR staff indicated that main areas affected by water damage were the file room, areas 270, 275, 313 and above the ceiling plenum over the support column along the north wall of the office. On the day of the assessment, all areas of the ceiling plenum surveyed were dry. No signs of standing water, mold growth or unusual odors were detected, however the plenum above area 270, had missing/damaged ductwork insulation and uninsulated copper piping (see Pictures 6 & 7). When warm, moist air passes over a surface that is colder than the air; water condensation can collect on the cold surface. Under these conditions water droplets can form, which can then drip from suspended surfaces. Over time, repeated water damage can stain ceiling tiles and lead to mold growth.

Plants were noted in several areas. Plants can be a source of pollen and mold, which can be a respiratory irritant to some individuals. Plants should be properly maintained and be equipped with drip pans. Plants should also be located away from the air stream of mechanical ventilation to prevent the aerosolization of dirt, pollen or mold.

Spaces were noted around the second floor exterior door near the fire escape. Light could be seen penetrating through this space (see Picture 8) and drafts were noted. The floor around this door is carpeted. Depending on wind and weather conditions, rainwater can penetrate through this space and wet carpeting and wallboard. On the day of the assessment, water damaged wallboard was noted near the baseboard in this area (see Picture 9). In addition, a number of areas had water coolers on carpeting (see Picture 10). Spills from the water cooler can result in wetting of the carpet, which can lead to mold growth.

The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur. Once mold has colonized porous materials, they are difficult to clean and should be removed.

Water damaged wallboard was also noted around the windowsill in area 221 (see Picture 11). Like other porous materials, if gypsum wallboard becomes wet repeatedly it can provide a medium for mold growth and is difficult to clean at best.

Other Concerns

Several other conditions that can potentially affect indoor air quality were also identified. Floor drains were noted in restrooms. Drains are designed with traps in order to prevent sewer odors/gases from penetrating into occupied spaces. When water enters a drain, the trap fills and forms a watertight seal. Without periodic input of water (e.g., every other day), traps can dry and compromise the integrity of the watertight seal. If traps dry out, sewer odors/gases can travel up the drain into occupied areas. The drain in the woman's restroom was clogged with debris and could not be checked properly (see Picture 12).

The copy room contains two photocopiers and other office equipment. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). No mechanical exhaust ventilation is provided for this room. Without mechanical exhaust ventilation, pollutants produced by office equipment can build up. Mechanical exhaust ventilation should be installed in this area to help reduce odors, pollutants and excess heat.

A personal air filtration unit was noted in one employee's work area (see Picture 13). These units are equipped with a filter, which should be cleaned/replaced as per the manufacturer's instructions. If not properly maintained, filters can become saturated and re-aerosolize dirt, dust and particulate matter.

As previously mentioned, the building has a history of roof leaks. Subsequent to the roof leaks, fiberglass insulation around ductwork was damaged and in some places removed or re-wrapped (see Pictures 14 & 15). A number of ceiling tiles were reportedly changed throughout the office. The condition of damaged fiberglass insulation around ductwork in the ceiling plenum coupled with the movement and replacement of ceiling tiles provides the opportunity for airborne dirt, dust and particulates to penetrate into occupied areas. Aerosolized dust, particulates and fiberglass can provide a source of eye, skin and respiratory irritation to certain individuals. In addition, these materials can accumulate on flat surfaces (e.g. desktops, shelving, carpets, etc.) below these areas and subsequently be re-aerosolized causing further irritation.

Another pathway of particulates into occupied areas is through open windows. A construction project is being conducted on the property adjacent to the DOR building (see Pictures 16 & 17). Construction vehicles can aerosolize large amounts of dirt, dust and other particulates. The open windows allow unfiltered outdoor air to enter the indoor environment that may transport airborne dirt, dust and particulates. Operating construction vehicles can also result in the entrainment of vehicle exhaust into the building, which may, in turn, provide opportunities for exposure to compounds such as carbon monoxide.

AHUs are normally equipped with filters that strain particulates from airflow. The filters provide filtration of respirable dusts. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent (Minimum Efficiency Reporting Value equal to 9) would be sufficient to reduce many airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increasing filtration can reduce airflow (called pressure drop) which can reduce the efficiency of the AHUs due to increased resistance. Prior to any increase of filtration, each AHU should be evaluated by a ventilation engineer to ascertain whether it can maintain function with more efficient filters.

The building has also had a problem with pests (see Picture 18). The OccuHealth Report found elevated levels of insect parts in air samples (OccuHealth, 2000). Insect parts can become dried out and aerosolized and may serve as a source of allergenic material for certain sensitive individuals. Under current Massachusetts law that will go into effect November 1, 2001, the principles of integrated pest management (IPM) must be used to remove pests in state buildings (Mass Act, 2000). A copy of the IPM guide is attached as Appendix A.

Conclusions/Recommendations

The symptoms reported at the Brockton DOR building (e.g. skin rashes, eye irritation) are consistent with what would be expected based on building conditions observed during the assessment. The presence of damaged fiberglass insulation in the ceiling plenum coupled with the "open" supply ventilation system and frequent changing/removal of ceiling tiles can create pathways for airborne materials (e.g. fiberglass fibers, dirt, dust and particulates) in the ceiling plenum to enter occupied areas creating conditions for exposure.

In view of the findings at the time of the visit, the following recommendations are made:

1. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of building occupancy independent of thermostat control.
2. In order to improve indoor air quality, an increase in the percentage of fresh air supply into the HVAC system may be necessary for some areas.
3. Consider replacing existing air diffusers with multi-directional diffusers that connect directly to ductwork (see Picture 19 for an example) forming a "closed" system.
4. Consider having the ventilation system balanced by an HVAC engineer.
5. Continue with plans to replace rooftop HVAC equipment. Contact BEHA's ER/IAQ program once HVAC renovations are complete to coordinate a follow-up assessment.
6. Change filters for AHU equipment as per the manufacturer's instructions or more frequently if needed. Examine AHUs periodically for maintenance and function.
7. Remove blockages from air diffusers (i.e. cardboard) to facilitate airflow.
8. Consider increasing the dust-spot efficiency of HVAC filters. Prior to any increase of filtration, each AHU should be evaluated by a ventilation engineer as to whether it can maintain function with more efficient filters.
9. Report any roof leaks or other signs of water penetration to the building manager for prompt remediation.
10. Once roof leaks are under control, replace any remaining water-stained ceiling tiles. Examine the area above and beneath these tiles for mold growth. Disinfect

areas of water leaks with an appropriate antimicrobial. Clean areas of antimicrobial application when dry.

11. Replace missing or damaged caulking and check seals on double-paned windows to prevent water penetration and potential mold growth. Once sources of water penetration are remedied, repair/replace water damaged wallboard/windowsills.

12. Ensure all plants are equipped with drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.

13. Relocate or place tile or rubber matting underneath water coolers in carpeted areas.

14. Keep windows closed during hot, humid weather to maintain indoor temperatures and to avoid condensation problems.

15. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

16. Examine fiberglass insulation around ductwork for mold colonization in areas that have or have had roof leaks on the second floor. If moldy, replace these materials and disinfect non-porous surfaces with an appropriate antimicrobial agent.

17. Conduct work above ceiling tiles during unoccupied periods or periods of low occupancy. Once work is completed wet wipe and/or vacuum area with a HEPA filtered vacuum cleaner to clean up all residual dirt, dust and particulates.

18. Consider consulting a ventilation engineer concerning the installation of local mechanical exhaust ventilation in the copy room or move to a well-ventilated area.

19. Ensure water is poured into floor drains regularly to maintain the integrity of the traps.

20. Use IPM to remove pests from the building. A copy of the IPM recommendations is included with this report as Appendix A (MDFA, 1996). Activities that can be used to eliminate pest infestation may include the following activities.

    i) Consult a licensed pesticide applicator on the most appropriate method to end infestation.

    ii) Reduce/eliminate pathways/food sources that are attracting rodents.

    iii) Reduce harborages (cardboard boxes) where pests may reside.

The combination of adjacent construction and the installation of new HVAC equipment can create conditions in which construction/renovation generated pollutants can be introduced into the building. In addition to the steps previously noted, the following recommendations should be implemented in order to reduce the migration of renovation generated pollutants into occupied areas. We suggest that these steps be taken on any renovation project within a public building:

1. Establish communications between all parties involved with building renovations to prevent potential IAQ problems. Develop a forum for occupants to express concerns about renovations as well as a program to resolve IAQ issues.
2. Develop a notification system for building occupants immediately adjacent to construction activities to report construction/renovation-related odors and/or dust(s) problems to the building administrator. Have these concerns relayed to the contractor in a manner to allow for a timely remediation of the problem.
3. When possible, schedule projects which produce large amounts of dusts, odors and emissions during unoccupied periods or periods of low occupancy.
4. Disseminate scheduling itinerary to all affected parties. This can be done in the form of meetings, newsletters or weekly bulletins.
5. Use local exhaust ventilation and isolation techniques to control for renovation pollutants. Precautions should be taken to avoid the re-entrainment of these materials into the building's HVAC system. The design of each system must be assessed to determine how it may be impacted by renovation activities. Specific HVAC protection requirements pertain to the return, central filtration and supply components of the ventilation system. This may entail shutting down systems (when possible) during periods of heavy construction and demolition, ensuring systems are isolated from contaminated environments, sealing ventilation openings with plastic and utilizing filters with a higher dust spot efficiency where needed (SMACNA, 1995).
6. Obtain Material Safety Data Sheets (MSDS) for all construction materials used during renovations and keep them in an area that is accessible to all individuals

during periods of building operations as required by the Massachusetts Right-To-Know Act (MGL, 1983).

7. Consult MSDS' for any material applied to the effected area during renovation(s) including any sealant, carpet adhesive, tile mastic, flooring and/or roofing materials. Provide proper ventilation and allow sufficient curing time as per the manufacturer's instructions concerning these materials.

8. Seal utility holes, spaces in floor decking and temporary walls to eliminate pollutant paths of migration. Seal holes created by missing tiles in ceiling temporarily to prevent renovation pollutant migration.

9. If possible, relocate susceptible persons and those with pre-existing medical conditions (e.g., hypersensitivity, asthma) away from areas of renovations.

10. Implement prudent housekeeping and work site practices to minimize exposure to renovation pollutants. This may include constructing barriers, sealing off areas, and temporarily relocating furniture and supplies. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended.

11. Consider changing filters for HVAC equipment more regularly in areas impacted by renovation activities. Examine the feasibility of acquiring more efficient filters for these units.

12. Close windows adjacent to outdoor construction activities generating dusts and/or odors.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

ASHRAE. 1992. Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 52.1-1992.

BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-308.1

Mass. Act. 2000. An Act Protecting Children and families from Harmful Pesticides. 2000 Mass Acts c. 85 sec. 6E.

MDFA. 1996. Integrated Pest Management Kit For Building Managers. Massachusetts Department of Food and Agriculture, Pesticide Bureau, Boston, MA.

MEHRC. 1997. Indoor Air Quality for HVAC Operators & Contractors Workbook. MidAtlanatic Environmental Hygiene Resource Center, Philadelphia, PA.

MGL. 1983. Hazardous Substances Disclosure by Employers. Massachusetts General Laws. M.G.L. c. 111F.

OccuHealth. 2000. Indoor Air Quality Assessment, prepared for Mr. Orazio DeLuca, Massachusetts Department of Revenue by Occuhealth, Inc., Mansfield, MA. May 10, 2000.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R. 1910.1000 Table Z-1-A.

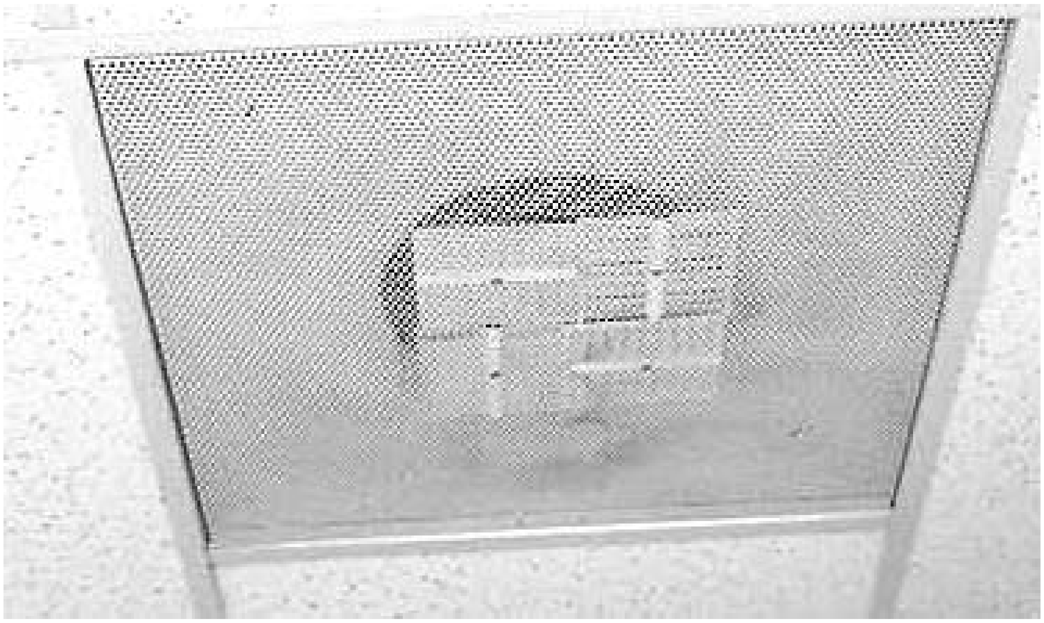
SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

Schmidt Etkin, D. 1992. Office Furnishings/Equipment & IAQ Health Impacts, Prevention & Mitigation. Cutter Information Corporation, Indoor Air Quality Update, Arlington, MA.

SMACNA. 1995. IAQ Guidelines for Occupied Buildings Under Construction. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc, Chantilly, VA.

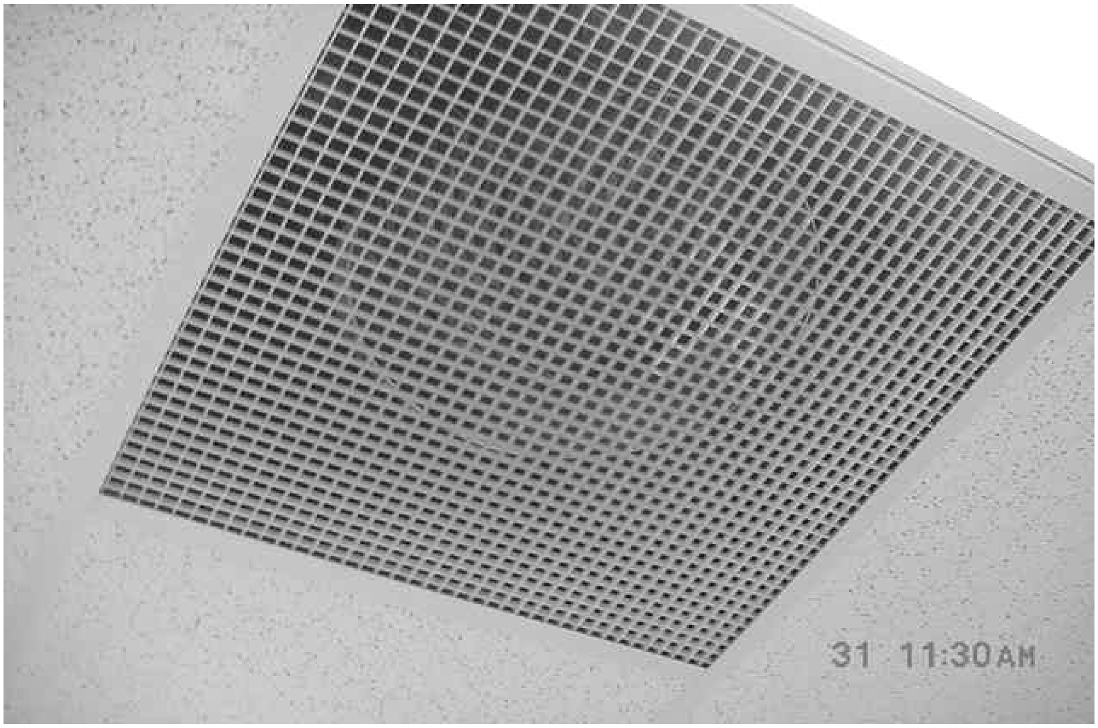
Thornburg, D. Filter Selection: a Standard Solution. *Engineering Systems* 17:6 pp. 74-80.

Picture 1



Example of Multi-Directional Air Diffuser: Note open Ductwork over Diffusers

Picture 2

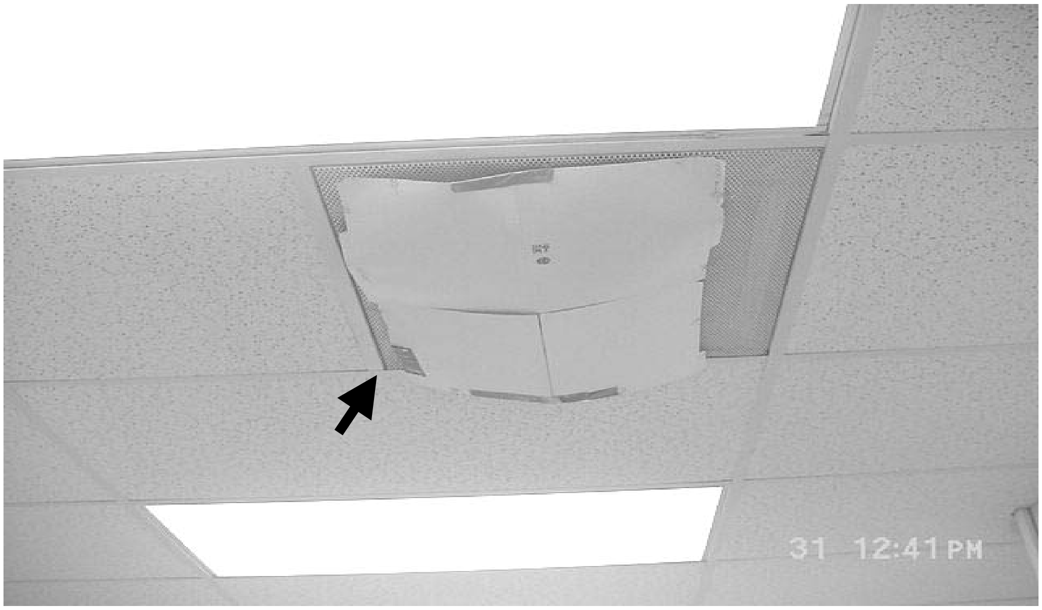


Ceiling-Mounted Exhaust Vent/Grill

Picture 3

Thermostat Located Directly above Printer

Picture 4



Air Diffuser Obstructed by Cardboard/Duct tape

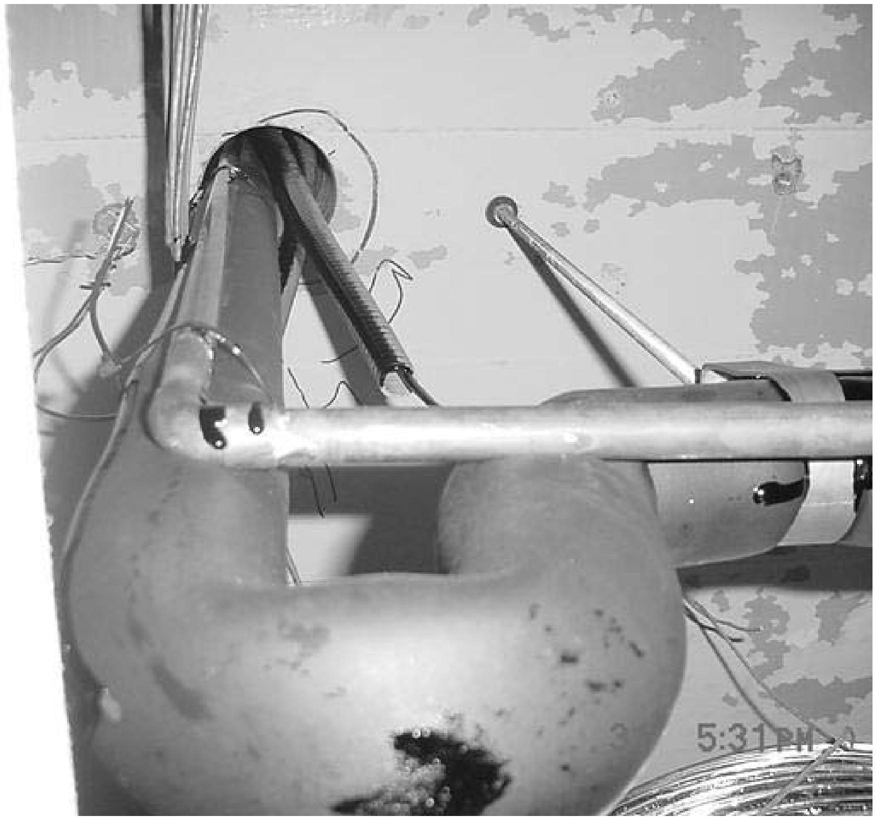
Picture 5

Plastic Sheeting Used to Direct Water Leaks into Trash Barrel in File Room

Picture 6

Partially Insulated Metal Ductwork Observed in the Ceiling Plenum

Picture 7

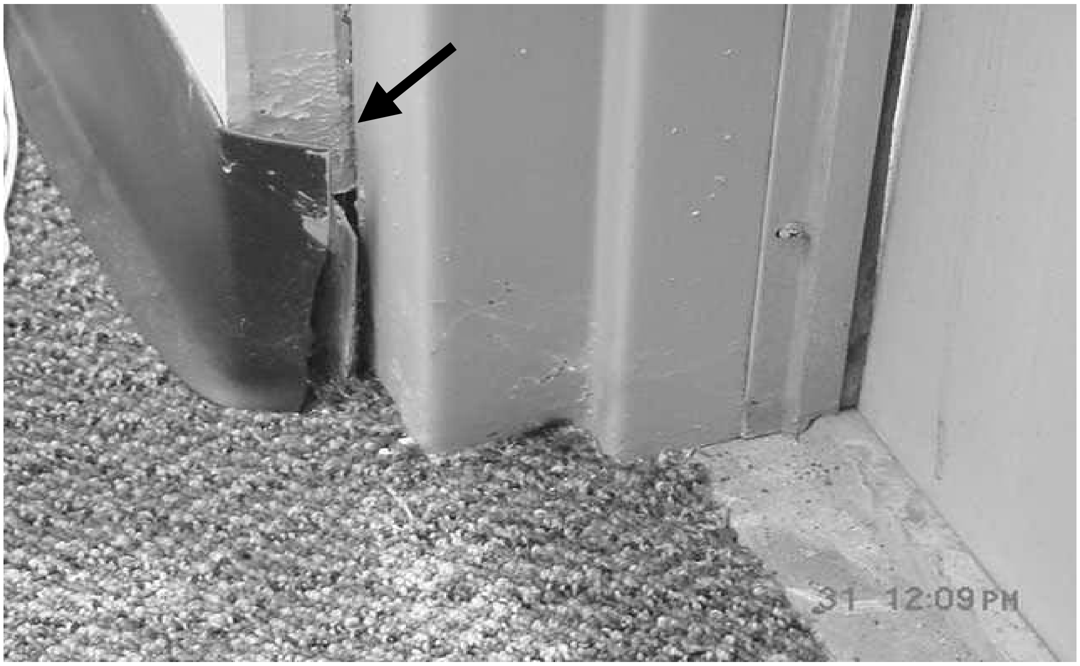


Uninsulated Copper Piping Observed in Ceiling Plenum

Picture 8

Space around Exterior Door on Second Floor: Note Light Penetration along Door

Picture 9



Water Damaged Wall near Exterior Door in Picture 8: Note Baseboard Pulling Away from Wall

Picture 10

Water Cooler on Carpet

Picture 11

Water Damage around Window

Picture 12

Clogged Floor Drain in Woman's Restroom

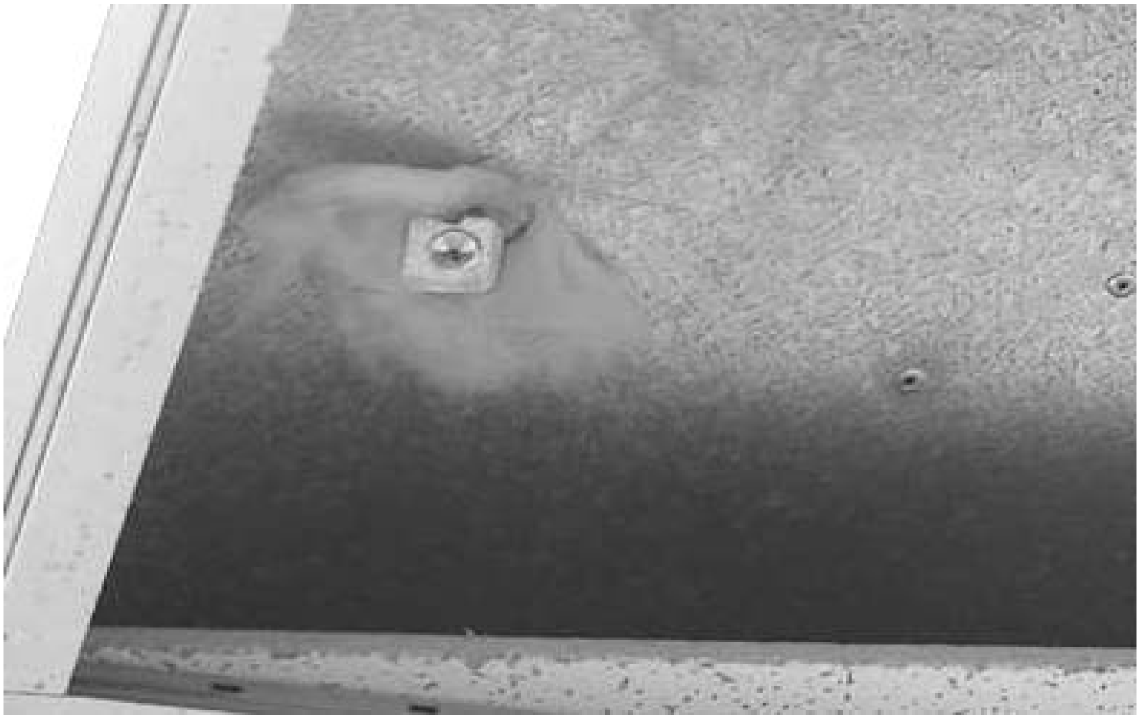
Picture 13

Personal Air Filtration Unit

Picture 14

Damaged Fiberglass Insulation above Ceiling Tiles

Picture 15



Area above Ceiling tiles where Insulation has been Removed from Ductwork, Note Fastener which held on Insulation

Picture 16

Opened Window in Area Adjacent to Construction Zone

Picture 17

Construction Area Adjacent to 10 Mulberry Street

Picture 18

Insect Trap Noted in Breakroom Behind Refrigerator

.

Picture 19

Example of Multi-Directional Air Diffuser
Attached Directly to Ductwork "Closed" System

TABLE 1

Indoor Air Test Results –Brockton Department of Revenue, Brockton, MA – August 31, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	455	79	69					Weather conditions: warm, sunny/scattered clouds
216	768	70	57	4	Yes	Yes	Yes	Dry erase board
Keefe	732	71	56	1	Yes	Yes	Yes	2 CT, 2 plants
Oberg C. (North)	707	69	55	0	Yes	Yes	Yes	Exhaust ducted, door open
218 (North)	699	68	56	0	Yes	Yes	Yes	
Sweeney	757	70	57	3	No	Yes	No	Supply off
220	881	73	53	2	Yes	Yes	Yes	Supply and exhaust off
221	811	71	52	1	Yes	Yes	Yes	Water damaged window panes
Shaw	769	72	54	1	Yes	Yes	Yes	Window open, air purifier
Bshara	790	73	54	0	Yes	Yes	Yes	
Grigas	740	72	50	3	No	Yes	Yes	CT, reported water leak

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results –Brockton Department of Revenue, Brockton, MA – August 31, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
275	707	72	49	0	Yes	Yes	No	
Scanlan	752	72	51	1	Yes	Yes	Yes	
276	767	71	53	1	Yes	Yes	Yes	
223	744	73	55	2	Yes	Yes	Yes	Temperature complaints-hot/cold, supply off
Wade	678	73	52	2	No	Yes	Yes	Supply and exhaust off
Fire escape area				0	Yes	Yes	No	Supply off
225	586	74	53	0	Yes	Yes	Yes	Supply and exhaust off, door open
227	594	74	54	0	Yes	Yes	Yes	Supply and exhaust off, door open
228	571	75	53	0	Yes	Yes	Yes	Supply and exhaust off
299	557	73	56	0	No	Yes	No	
229	566	73	55	1	Yes	Yes	Yes	Supply and exhaust off, window and door open

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results –Brockton Department of Revenue, Brockton, MA – August 31, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Fleming	580	73	57	1	Yes	Yes	No	Supply and exhaust off
Lee	561	72	59	1	No	Yes	Yes	Diffuser covered due to cold/particulates
231	560	71	59	0	No	Yes	Yes	Exhaust off
318	563	71	57	1	No	Yes	Yes	Printer under thermostat
Typing station	586	70	58	1	No	Yes	Yes	
Corridor near exit								Loose ceiling tile
Copy room	553	71	60	0	No	Yes	No	2 photocopiers and other office equipment
Law Library	566	70	61	0	No	Yes	Yes	
Boss	567	71	61	1	No	Yes	No	
Pizzanello	603	71	57	1	No	Yes	Yes	
File Room	589	71	56	0	No	Yes	Yes	Active water leaks, file cabinet covered with plastic, ceiling tiles

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

TABLE 4

Indoor Air Test Results –Brockton Department of Revenue, Brockton, MA – August 31, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
								changed
Small file room (214)	526	72	56	0	No	Yes	No	Door open
Training room	528	71	56	0	Yes	Yes	Yes	Exhaust off
Break room	664	70	53	5	No	Yes	No	2 supply diffusers, 1 CT
Men's Restroom						Yes	Yes	Ant trap, dry drain trap
Ladies Restroom						Yes	Yes	Floor drain closed
208 – Storage	664	70	54	0	No	Yes	No	Missing ceiling tile
240	664	71	53	1	No	Yes	No	
Reception	670	71	53	1	No	Yes	No	Water cooler on carpet
Cubicle outside of room 204	647	70	53	1	Yes	Yes	Yes	Exhaust off
Raposa	638	70	53	0	No	Yes		

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 5

Indoor Air Test Results –Brockton Department of Revenue, Brockton, MA – August 31, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
270	670	71	53	4	No	Yes	Yes	
O'Neil	688	71	52	4	No	Yes	Yes	

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%